Section of Epidemiology and State Medicine.

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The Ventilation, Heating and Lighting of Hospital Wards.

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ABSTRACT.—*History* of ventilation in last 100 years, showing reversal of ideas and influence of sanatorium idea.

Physiology of cool moving air. How it affects metabolism, heat-loss and heat-production. Relation to sunlight. Reactive capacity of the individual.

Practice of these teachings, as illustrated by sanatorium treatment of tuberculosis and by open-air schools. Exposure to cooling air a powerful therapeutic agent. Infrequent occurrence in sanatoria of diseases or complications often ascribed to cold. Dilution of infection. Applicability to diseases other than tuberculosis. Shock and old age.

Perflation and diffusion, their relative values. Uniformity or variability of effect desirable? Incompatibility of good ventilation and ordinary standards of heating. Former the more important. Conclusion that ward temperatures may be lowered without harm. Measures necessary to compensate, clothing, classification of patients, small wards. Changing standards of comfort. Psychological effects.

Systems of ventilation in hospital wards. Mechanical by propulsion or extraction being displaced by natural system, usually by cross-window ventilation. Supplementary ventilators. Objection to heating of incoming air. Fallibility of human factor in management. Sash versus casement windows. Hoppers. Austral window. Orientation and exposure of wards. Ventilation of small wards. Proportion of window space to solid wall. Balconies. Floor space.

Heating of wards. Heating of air or floor or walls. Open fires. Value of radiant heat. Steam or water under low or high pressure. Radiators or pipes.

Lighting. Avoidance of glare from windows. Arrangement of beds in wards. Colour of walls. Blinds and curtains. Artificial lighting.

IT is commonly assumed that the ventilation and heating of tuberculosis sanatoria are peculiar to that type of hospital and have little application to general and fever hospitals, whose conditions are supposed to be different. It is important to try to determine whether this assumption is correct or whether the same principles, the application of which produces such striking results in tuberculosis institutions, should not also be applied in equal degree, or at least to a greater degree than at present, in general medical and surgical hospitals, and in fever and other special hospitals.

At the outset it is necessary to refer briefly to the recent history of the science of ventilation and the medical theories bearing on it. To do so will at least suffice to show how much is yet to be learned, and how little we can claim for the finality of our present views. It is less than a hundred years since Dr. Bodington, of Sutton Coldfield, was protesting against the antiphlogistic lowering methods of treatment and the practice of shutting up the sick in closed rooms. Air was then regarded as a dangerous element to be kept away from wounds. Cold air on the skin or in the lungs was particularly to be avoided by the sick. The idea—then firmly rooted—that many illnesses were caused by a chill, survives to some extent even now as a cloak for our ignorance. Lister's antiseptic sprays and the generally held theories about the conveyance of infections by the air continued to prejudice men's minds against the atmosphere surrounding them. With the development of hygiene as a science, there grew the idea that the air to be breathed by the sick must be filtered, warmed, and moistened, delivered to them without draught and without excess of carbon dioxide or organic emanations. Such views encouraged the use of mechanical systems of ventilation. Then the sanatorium idea of the treatment of at least one disease in the open air began to take root in England half a century after it was first preached. Along with this the work of Flügge, Haldane and Hill,

on the physiological action of moving air completed the revolution. Now we have reached the stage when mechanical systems of ventilating hospitals and schools are being scrapped and natural cross-ventilation holds the field. Carbon dioxide, so far from being dreaded, is now used to stimulate respiration. Such a rapid succession of different views makes one wonder what the position will be in the course of another generation.

The existing standards of ventilating and heating hospital wards are determined very little by medical considerations, but are based on the habits of the community generally in regard to clothing and the temperature at which living rooms are kept.

Although medical practitioners and nurses are taught a little about the place of ventilation in hygiene, yet relatively it is a neglected subject. After the architect and the builder, guided perhaps by medical advice, have settled the form and degree of the ventilation of a general hospital, it is seldom that anyone takes any serious interest in it thereafter. In a fever hospital questions of cross-infection and dilution of infection compel greater attention to the ventilation of the wards, but it is only in tuberculosis institutions that ventilation gets consideration as the therapeutic agent which it undoubtedly is.

Before discussing the practical aspects of the question, we ought to consider what good ventilation is and what it does. It may be taken as proved that within fairly wide limits the chemical purity of the atmosphere, its content of carbon dioxide or oxygen or organic matter, are of much less importance for health than certain physical factors which influence the loss of heat from the human body. Life would be impossible without the faculty of shedding heat. The three chief ways in which the body gets rid of heat are by conduction and radiation to the colder medium surrounding it, by evaporation of moisture, visible or invisible, from the skin, and by warming the expired air and evaporating moisture from the respiratory membranes. Increase of heat-production within the body, as in muscular exertion or in pyrexia, is followed almost immediately by increased heat loss, and incidentally by increased consumption of food and oxygen or alternatively by loss of body-weight. Conversely, increase of the heat loss stimulates heat-production, calling for more food and oxygen, increasing appetite and the excretory processes. I may quote as an example the statement of Hill and Campbell[1] that the metabolism of children lying nude in the open air in summer at Alton was 50% above the standard figures for closed chambers, and in Switzerland the metabolism of children lying nude and exposed to the open air was sometimes increased over 100% when there was snow on the mountains. The same authors state that cool conditions, e.g., sleeping out of doors, double the evaporation of water from the respiratory membranes.

Much importance is now being attributed to the effect of sunlight on health and on such diseases as tuberculosis and rickets. Patients who are being deliberately treated by light, artificial or natural, have at the same time a large area of skin exposed to the air, and I am not sure that a large part of the beneficial effects observed is not due to the latter factor. Exposure to bright sunlight without movement of cool air may be the opposite of beneficial in many persons.

To obtain benefit from good ventilation a certain reactive or regulating capacity is demanded of the organism. In certain states of health, particularly in shock, this power of response is grossly defective, and in certain conditions of civilization it is rendered sluggish through partial disuse, but it can be affirmed that in the great majority of both the healthy and the sick, it is perfectly adequate or is easily capable of re-education. The problem of ventilation is the problem of utilizing this powerful exciter of metabolism within the limits of the reactive capacity of the individual. It does not, I presume, require arguing in these days that increase of metabolism, causing increased intake and assimilation of food and oxygen, is the

[1] Hill and Campbell, "Health and Environment," p. 200.

best means of repairing damaged or unhealthy organs or tissues and of securing the elimination of the ultimate waste products and the products of bacterial action. This, of course, is almost the exact contrary of the "lowering" methods of treatment by bleeding, purging, and antimony tartrate, so long in vogue.

How these principles of physiology are put into practice is best illustrated by the sanatorium treatment of tuberculosis. Here are patients of all ages, suffering from acute or chronic forms of a bacterial disease affecting chiefly the respiratory organs, but also the bones, joints, glands, kidneys and peritoneum. It has been well established now for over thirty years that the various forms of this disease, no organ being excepted, are best treated under what may be called open-air conditions, conditions where the temperature surrounding the patient is of relatively little importance, so long as he is exposed to moving air, producing a cooling effect. The increased heat-loss stimulates heat-production within the body, and increases appetite considerably. This great principle, along with the equally important one of rest for the diseased organ, is the basis of sanatorium treatment, and produces remarkable results in reducing toxæmia, improving nutrition and causing retrogression of the disease deposits. Can methods which produce such results in one multiform disease not produce equally remarkable results in other diseases? Are we failing to utilize in the latter a factor which would accelerate recovery? Is improvement in nutrition and general health not equally desirable in the patient recovering from gastro-enterostomy or diabetes or diphtheria?

It is true that sanatorium practice in recent years has changed somewhat in the direction of providing greater comfort for the patient. Exposure to the open air is less drastic than it used to be, and more provision is made for heating wards. Simultaneously the practice in general hospitals has tended to move in the opposite direction, to provide fresh air at a lower temperature than was formerly thought necessary. There is still, however, a very wide gap between the two for which it is difficult to find sufficient justification.

Abundant ventilation in open-air hospitals is not synonymous with draughts. Sir Henry Gauvain has shown in his new buildings at Alton how the completest exposure to fresh air and sunlight can be combined with necessary warmth and comfort. Draughts are not essential in sanatorium treatment, although in moderate degree they do no harm. The fear of cold is deeply rooted in people's minds, and certain diseases are particularly associated with exposure to cold, mainly perhaps because of the chilly feelings which usher them in. Pleurisy is such a disease. Naturally it occurs frequently in sanatoria because it is part and parcel of pulmonary tuberculosis, but it occurs in my experience just as frequently in summer as in winter, and more frequently in the patient's own home than in a sanatorium.

Lobar pneumonia is practically unknown in sanatorium practice. In an experience of twenty years and covering about 12,000 sanatorium cases, I cannot recollect a single case of lobar pneumonia among them. Yet in the early weeks, at least, of their sanatorium treatment, there must have been among them as high a proportion of pneumococcus carriers as in the general population from which they came. They were plunged into the ordinary conditions of exposure to sanatorium weather without any mitigation or gradual acclimatization. They ranged from 15 to 65 or more years of age. The initial discomfort which they often feel in winter generally disappears quickly, and their symptoms of illness as a general rule begin to ameliorate from the time of admission.

Bronchitis is occasionally aggravated by sanatorium conditions in winter, but more frequently improves steadily with the improvement in both the general health and the tuberculous disease. Colds in the head occur in sanatoria in very small epidemics when infection is introduced from without. Neither the general nor the local symptoms are any worse under sanatorium conditions in winter than in an ordinary household. Where the coryza is complicated by tracheitis or bronchitis,

this occurs no more frequently and takes no longer for recovery in patients nursed in open-air wards even when the temperature ranges somewhere between 30° and 50° F. than in patients nursed in their own homes at much higher temperatures and with much less exposure to moving air. It seems that it is less the low air temperature that aggravates the symptoms of a coryza than alternations of high room temperature and low external temperature in winter.

Chilblains occur fairly frequently in winter and may be uncomfortable, but such a trivial complication cannot be set against the great benefit which the open-air régime confers on the health of the patients. It is no part of sanatorium treatment to keep its patients uncomfortable. If they are, it indicates some avoidable failure on the part of the staff or of the patients themselves.

Rheumatic conditions, so often associated in the minds of the public with cold, are occasionally complained of by patients. Only twice, I believe, have I seen subacute rheumatic fever develop among my patients, and I suspect that rheumatism in its various forms is less common in sanatoria than among the general population. In two children's hospitals with which I am acquainted tuberculosis and acute and subacute rheumatism are treated under almost similar conditions in regard to ventilation and heating. In the acute stages the rheumatic cases are treated in freely ventilated and only moderately warmed wards, and in the convalescent stages either on open balconies or verandahs, or in wards identical with those for tuberculous cases.

In regard to the infectious diseases, spread mostly by spray infection, the degree of ventilation in sanatoria so dilutes the infection that it is rare for an epidemic to gain more than a very small footing. During the recent epidemic of influenza 1% of my patients and 25% of my staff were affected. The all-important part that good ventilation plays in preventing cerebrospinal meningitis in barracks is well known to you.

If, then, one is justified in claiming so much benefit to the general health, and such an absence of adverse effects from the degree of ventilation practised in sanatoria and open-air schools, the question ought to be discussed how far the same practice is likely to have similar results in other disease conditions. In certain fever hospitals such treatment is already being given to convalescents with excellent effect. In children's hospitals, too, there is a greater tendency to expose patients on balconies and verandahs, perhaps more for treatment by sunlight than by fresh air. In the earlier part of this century a good deal was written about the value of open-air treatment of cases of pneumonia and the most conflicting opinions were expressed. For example, G. D. Head,[1] from an experience of American military hospitals in war-time records a mortality of 13·9% among cases of influenzal pneumonia treated by open-air methods, and 3·2% among those treated in closed and warmed wards. But it is clear that the open-air methods were unduly drastic, and further the first figure was obtained during the early part of the epidemic when one expects a higher mortality, and the second figure in the later part of the epidemic. Oskar Kudelka[2] on the other hand obtained much improved results by treating pneumonia in infants by open-air methods.

Cases of cardiac disease have been treated in recent years by several physicians on open-air lines. On theoretical grounds one would expect benefit in such cases, since cool air playing on the skin improves the cardio-vascular tone, and by contracting the skin vessels and keeping the blood-supply mainly in the internal organs lessens the strain on the heart, while improving oxygenation and metabolism.

Exposure to cold has generally been regarded as one of the causes of nephritis, hence one would be chary of departing from orthodoxy in treating this disease or a disease like scarlet fever, with a marked tendency to be complicated by it. But in

[1] *Journ. Amer. Med. Assoc.*, 1919, lxxii, 1268.
[2] *Wien. Med. Woch.*, 1932, lxxxii, 969.

all those diseases in which the authorities recommend warmth and a constant room temperature, they also advise free ventilation, although without draughts. There are those who deny any special relationship of cold to nephritis.

Cases of surgical shock following operation or burns or laceration of tissues appear to be in a class by themselves. The lowered blood-pressure does not seem to depend on vasomotor paralysis, and the usual response of the vasomotor system to the stimulation of cool air is lacking. Similarly very old and very feeble patients have poor reactive capacity, and should be treated under warm sheltered conditions.

With these few exceptions I submit that something approaching sanatorium conditions would be to the advantage of the great majority of hospital patients. Who would not agree that increase of appetite and improvement in the condition of the blood, effects which almost invariably follow exposure to the open air, would not also be of value in the majority of medical and surgical diseases? Pyrexia is no contra-indication, but is rather an indication for it. The provision of balconies and verandahs, although making such treatment easier and pleasanter is by no means essential, and unless well planned may be a disadvantage.

It seems a little absurd that patients of all ages and degrees of infirmity, and suffering from a great variety of diseases, should receive identical treatment in respect of the very important medium enveloping them. In the large wards which have been favoured in England, the ventilation must necessarily be a compromise determined like the strength of a chain by the weakest link. It seems reasonable to provide the treatment most suitable to the needs of the individual, and I suggest that this could best be secured by providing a higher proportion of accommodation in small wards, in which selective treatment would become possible.

Diffusion of air alone, although with large openings it may be sufficient to keep the chemical composition satisfactory, is nevertheless not enough for good ventilation. It does not as quickly as is necessary remove the layer of heated air in contact with the skin. For this some movement of the body of air is required. Air in uniform movement, causing monotony of sensation, is regarded as less stimulating and beneficial than air varying in velocity, and possibly also in temperature. Slow mass movement with such small variations, "puffs of air this way and that," provides better ventilation than strong currents of air coming through small openings and causing marked local cooling. The most comfortable and at the same time probably most efficient ventilation is secured in a shed or room of which one side is completely open, while the other three sides, although provided with fanlights, can be completely closed. On windy days the velocity of the moving air is reduced to reasonable limits, whether the open side is towards or away from or oblique to the direction of the wind. On still days free diffusion plays the chief part, aided by such cross movements as can be secured between the open front and one or more fanlights in the opposite wall.

The cooling effect on the body which is desired is attained either by the coldness of the air or by its movement. Cold still air does not long remain cold in contact with the warm body, hence in practice it is the movement of air at a temperature below that of the body temperature that matters most in regard to ventilation. A greater velocity of movement is naturally required the higher the air temperature. With really cold air a little goes a long way to provide the conditions of good ventilation, and protection from too great velocity becomes important. Such protection out of doors is of course provided by increasing the clothing. Indoors it is generally attained by cutting down air movement, for example, by closing windows. Our problem is to secure such a degree of movement of the air as will stimulate metabolism by abstraction of heat from the body, without interfering with the patient's comfort to such an extent as to depress his vitality by excess of heat-loss or to excite in him a hostile mental attitude which would tend to counteract the benefit of the treatment.

It follows from my argument that there is essentially a conflict between good ventilation and good heating as ordinarily understood, indeed that the two are incompatible in practice. Usually the ventilation is sacrificed to the temperature of the ward, but I hold that the ventilation should be the first consideration and that the ward temperature is a secondary matter. The old standards of ventilation handed down from one textbook to another, and based mainly on the carbon dioxide content of the air and on the standard of comfort demanded, required that the air of a room in which each person had 1,000 cubic feet of air space be changed at least three times an hour. Rosenau states that air moving at a greater velocity than 1 to 2½ miles an hour, that is 1·5 to 3·5 feet per second, according to the outside temperature, causes the sensation of a draught. If the whole body of air in a room were moving at even the smaller of these velocities, it would be changed at least one hundred times an hour. The latter standard corresponds much more closely than the former to the conditions under which tuberculous patients thrive and get well.

One has to consider the psychological effect of any form of treatment on the patient. A continuous stream of unpleasant sensory impulses is not likely to conduce to recovery any more than continuous pain. Children are little affected in this way, and stand exposure to cold remarkably well, as can be seen both among healthy children and among ailing children in open-air schools and hospitals, where the amount of clothing required is surprisingly small. Comfort has to be studied rather more in the adult. But what may at first be regarded as discomfort is soon borne cheerfully and without any harm if the patient is satisfied that thereby his ultimate good is going to result. It has to be emphasized that exposure to cool air is a mode of treatment and that the body adapts itself very quickly to such a change of conditions.

In this country it is generally held that the ward temperature should be between 60° and 65° F., the optimum temperature for comfort being 62° F. In America the standard demanded for comfort is generally higher, even as high as 70° to 75° F. Obviously these figures are partly dependent on habit. The view now advanced is that ward temperatures can be reduced below those standards not only without harm to most patients, but actually with benefit to their general health and the rapidity of their recovery. Naturally, adjustments in other directions would have to be made. Extra blankets, warm bed jackets, bed socks and gloves and, in a few cases, woollen helmets would have to be available for need. The dietary would probably have to be increased to meet the increased metabolism. Patients would have to be better classified than at present. Those requiring more shelter and warmth would have to be segregated in small wards.

Mechanical systems of ventilation by propulsion and extraction of air have many attractive features where equable conditions of temperature, humidity and velocity of air movement are desired, as in an operating theatre or a place of entertainment, but in hospital wards, where equable conditions are unnecessary and possibly undesirable, they have quite gone out of fashion both in England and abroad. Whatever system of ventilation is used, it is less frequently the equipment than the human management of it that is faulty.

Most hospitals now depend on cross-ventilation of wards by windows, often combined with the ventilating effect of open fires or stoves, and sometimes with wall ventilators opening behind radiators. Tobin's tubes and Sherringham's valves survive in old buildings and in the textbooks. Fireplaces or stoves in the middle of wards have mostly gone also, not because of inefficiency, but because of their obstructiveness and effect in increasing the width and the cost of buildings. Window ventilation by itself can provide any degree of ventilation required if it is used intelligently. Too often the fear of draughts leads to the closing of windows except in really warm weather. Ventilation openings behind radiators are closed at the

beginning of winter and are forgotten afterwards, accumulating a deposit of dust and fluff in an inaccessible position. Windows are closed while a patient is stripped for examination or for blanket bathing, and the nurse forgets to open them afterwards. So long as such things are regarded as of little importance, any system will give bad results. But if we elevate good ventilation to its proper place as a therapeutic agent, a form of physical medicine which is a valuable adjuvant in the treatment of the sick, and train medical students and nurses in its principles and application, then even the provision now made by architects will be found generally satisfactory.

The practice of heating the incoming air is, I am glad to say, becoming less favoured. In view of the teachings of physiology, it seems to me to be wrong in principle, unless it is limited to taking the chill off very cold air.

With regard to the form of window, sash windows are still being used more than casements in large wards. The double hung sash, made of good materials and hung on chains, is easy to manipulate and to clean. It does nothing to break strong currents, and of course allows only half the window space to be open. Casements allow practically the whole space to be opened, but may not be regarded as suitable in mental or children's hospitals in view of the risk that patients may fall out. Casements ought to open outward, even if they are more difficult to clean, because they can be adjusted very well to regulate the entering current of air, and because it is easier to make them raintight. Variations in the direction of the wind can be met by opening one or other half in varying degree, so as to interpose a baffle or barrier against too strong a current. Particularly to be welcomed are the newer designs of casement window, vertically pivoted about a third of the distance from its edge. Such a window, combined with friction joints and a fastening on the principle of the inclined plane, gives a degree of comfort to window ventilation not previously attained. Their use demands less intelligence and less constant attention than does ventilation by sash windows, while the noise of rattling stays and the danger of breakage in a high wind are practically eliminated.

The ward window, whether of the sash or of the casement type, is best completed above by a hopper, hinged below and opening inward to a considerable angle. Side cheeks of glass are a necessary evil, in order that the cold entering air may not fall directly down on the patient, but may be directed upward and distributed from the ceiling. Some windows are now made with a similar, but considerably smaller, hopper along the lower part of the window, which serves something of the same purpose as the Hinckes-Bird device for sash windows. It is generally agreed that ward windows should be low enough to allow bed patients to see out, that is, within 33 in. or at most 36 in. of floor level, and should extend within a foot of the ceiling for the sake of good lighting and ventilation from the ceiling. If, however, they extend too near the ceiling, the latter tends to become stained with the rain, and the amount of glare from the sky is apt to trouble patients facing the window. If it is thought necessary to provide wall ventilators, I should prefer these to be near the ceiling, sloping upward and inward, and with an impermeable lining. The inner grating should be detachable for periodical cleaning, and there should be no means of closing it.

Another type of window which has been commended by the Scottish Board of Health, but of which I have no personal experience, is the Austral window, the two sashes of which are horizontally pivoted so as to direct the entering air upward and to keep out rain.

Hitherto we have had chiefly in mind the conventional large ward of twenty or thirty or more beds with its long axis north and south. In general hospitals the tendency towards smaller wards, already mentioned, has got little further than the provision of side wards of from one to four beds. In fever hospitals also, the growing demand for isolation accommodation has led to the provision of more small wards. Although large wards allow better supervision of patients and a slight economy of

service, they are inferior to a system of small wards, in several respects. The latter allow much better classification of patients according to their disease and the requirements of treatment, their age and social or educational position, and so contribute greatly to their comfort and happiness. They become more useful the more patients are expected to contribute to the cost of their maintenance according to their means. It might be thought that the ventilation of large wards would be easier by means of opposed windows, but my experience is that the ventilation of small wards gives less trouble and more comfort, and that individual needs can be better dealt with in the way of providing extra warmth and freedom from draughts in cases where such is required. Small wards, each of four beds, solve many problems of ventilation and lighting where the beds can be placed parallel to the window. It is easier to approach the ideal of one side being completely open while the opposite wall, generally opening into a corridor, can have as much or as little glass as is desired for supervision, and one or several fanlights for cross-ventilation on still days. The bogy of dead or unventilated spaces can easily be overcome by proper use of the windows and fanlights. The newer architecture allows much more window space relatively to solid wall. A report to the Royal Institute of British Architects[1] on the orientation of buildings contains the following statements: "Whilst public opinion is demanding the most ample admission of light, air and sunshine to the interiors of domestic, factory and office buildings, hospital wards are still being planned with over 60% of the external wall space taken up by solid brickwork. . . . Wards are now being erected in this country where the actual amount of solid wall now occupies only 34% of the wall surface instead of 70% as in the older type of wards. The Committee are informed that the additional cost of maintaining the necessary minimum temperature in view of the larger window area has been carefully investigated, and is considered to be immaterial." These are the views of a strong committee of experts.

If balconies are desired they should be quite narrow, say from 3 ft. to 5 ft. Wide balconies and roofs of verandahs undoubtedly cut off an undue amount of light and ventilation from rooms below.

Objection may be taken to small wards on the ground of increased capital cost, but it must be taken into account that the segregating effect of partition walls and the higher standard of ventilation which it is suggested can be attained make possible a greater density of beds. Even allowing for a central corridor of 8 ft., the floor space per patient need be no more than 100 sq. ft., and indeed may be as low as 86 sq. ft. without harm in general hospitals. Within limits, floor space may be reduced in proportion as the ventilation is increased.

So-called "verandah-wards" have been recently designed which are claimed to combine the advantages without the disadvantages of the ward with a verandah. The Dosquet ward described in the German literature is such a ward. In England another is described in the Report to the Royal Institute of British Architects already referred to, which is only 20 ft. wide, and has the side walls mainly of folding glass doors, allowing complete access of sunshine and air from both sides if desired. It is divided by partitions, mainly of glass, into cubicles, each with four beds, parallel to the outside windows, and allowing ample corridor space along one side of the ward.

Heating.—The heating and ventilation of hospital wards are so interdependent that they cannot be discussed apart, and several points in regard to heating have already been referred to. German writers have certainly gone very fully into the engineering details, but it is difficult to accept the dictum of Schmieden that the problem of heating is now solved, but not that of ventilation. We would all agree, I believe, with the conclusion of the New York State Commission on Ventilation that overheating constitutes the chief ill-effect of air upon health. Overheating of rooms has long been recognized as one of the chief causes of respiratory catarrh. The best

[1] *Journ. R.I.B.A.*, Sept. 10, 1932, p. 777.

source of heat is a person's own body, and the only problem that ought to arise is that of regulating its loss or conservation by ventilation and clothing. But a hospital patient is not in the position of a healthy person, who can by muscular exertion multiply the heat-production of his basal metabolism by ten to fifteen times, or even in the position of the child in an open-air school who alternates periods of lessons and physical exercise. For him some supplementary heat is necessary in winter, although not to the extent that is commonly believed necessary.

Heating of the air to be breathed is founded on a wrong principle, and is, in addition, uneconomical. From personal experience we know that if the feet, the hands and the ears are kept warm, the rest of the body will look after itself. Recognizing the importance of keeping the feet warm, certain schools and churches warm the floor to a temperature of from 70° to 75° F. Three sanatoria, to my knowledge, supply warmth to their ambulant patients in dining rooms in the same way. In the King George V Sanatorium a hot-water pipe just above floor-level under each dining table gives entire satisfaction. For patients in bed, electrically heated mattresses were formerly used by Sir Henry Gauvain at Alton, but in general hospitals and in most private houses a sufficiency of blankets, along with bed socks, achieves the same end. It is the patient's head and upper extremities that require some extra heat in winter. If a mild beam of radiant heat could be focused on those parts the problem would be solved. Panel heating by hot-water pipes embedded in the ceiling or in the walls is said by Vernon to confer the same degree of comfort with a room temperature of 55° F. as heating by convection to 65° F. Radiant heat has little effect in heating the air through which it passes, and is therefore claimed to be the more economical. The technical difficulties of heating hospital wards by radiant heat have not yet been satisfactorily solved, and the older methods of heating have still to be relied on.

Under ordinary circumstances an open fire in a large ward is something of a luxury. Its ventilating action should be unnecessary with cross-window ventilation even moderately well managed. A fire is a necessity if there is no day-room for convalescent patients, and it provides for those sitting around it a comfortable source of radiant heat. Otherwise, unless it is arranged to deliver a flow of heated air in the ward, it does little more than pretend to heat the ward. Even this and its admitted cheerfulness may justify its use in a large ward freely ventilated in the way I have suggested. Where fires are used in wards they are best placed at either end.

The objections to steam heating of wards are many—the musty, stale smell, as unappetizing as the conditioned air of the tube railways, and the complication of guards to prevent burns being the chief. High-pressure hot water has very similar defects. Almost universally employed now is heating by low-pressure hot water, usually circulated by pump from a central boiler house. A radiator under each ward window is the usual mode of distributing the heat. For my part I prefer pipe heating, as being cleaner and ensuring more even distribution of the heat. As it passes under a window and under the bed head the pipe gives off enough heat to bear up and allow to be sufficiently mixed the cold air entering at the top of the window. A radiator is likely to cause a rising current strong enough to divert the cold air down on the bald head of an adjoining patient. A new form of radiator with a flat surface, spread over a larger area and applied closely to the wall, is really a form of panel heating, which offers hope of avoiding the objections of the other systems. In theory, radiators in the centre of a ward should give off more radiant heat and be preferable to wall radiators, but in practice this is not so, and two hospitals of which I know have recently decided to go back to wall radiators.

Lighting.—On this subject I am not aware that there is much controversy except on details. With regard to daylight, the ideal to be aimed at is the maximum of diffuse light without glare. The orientation and surroundings of the hospital are

relevant factors. In most cases hospital wards face east and west, since a south aspect generally makes the ward uncomfortably hot in summer, and allows less of the floor and walls to be swept by direct sunlight than where the ward faces east and west. For the same reason the administration blocks should be at the north end of the wards. It is better to use the south end of the ward as a sun-balcony or day-room, instead of placing the sanitary accommodation there.

Sanatorium wards generally face south, or a little east or west of south, which may be of some advantage in winter, and is not of much disadvantage in summer because of the copious ventilation which is possible. Convalescent wards in sanatoria may well face east and west.

Glare from the sky is often troublesome, especially in infectious diseases with complications of the eye. The discomforts of glare and of reading in face of a bright source of light may be unsuspected causes of fatigue and headache. The really sick patients are most likely to suffer, since many of them, particularly the surgical cases, are compelled to lie or recline on their back. Naturally glare is less troublesome where the ward faces other buildings or a screen of trees. The higher the windows go to the ceiling, the greater the discomfort from glare. On upper floors especially, it may be an advantage to place the beds parallel to the windows, a practice that is commoner abroad than in England. Discomfort from glare is almost entirely avoided in the small wards which I commended earlier.

The question of blinds and curtains deserves mention. Wherever possible, these should be dispensed with, for the sake of good ventilation and cleanliness, as is the practice in most sanatoria. Patients generally accustom themselves quickly to sleeping in the evening and morning daylight in summer, but it is recognized that very sick patients may be fretted by too much light and may suffer from the absence of blinds at a critical stage in their illness, for example, before operation. For them again selective treatment in small wards would solve the difficulty. The necessities of nursing in wards overlooked by other buildings may make blinds or curtains inevitable. Each case must be considered according to its circumstances.

The colour of walls in hospital wards has a good deal to do with the efficiency of the lighting. It is now generally reckoned an advantage to use colours which will show dirt rather than hide it. Very light colours, such as pale green or cream, combine a pleasing effect with nearly the maximum reflection of light. Ceilings should be lighter still, generally a "broken" white.

The supply of artificial light should not be niggardly. General ward lighting, by reflection from the ceiling, can be made quite satisfactory when carefully arranged, but generally wall lighting is preferred. Electric light should be supplied over each bed by a wall bracket and a shaded lamp, with the switch accessible to the patient. Such a light at a height of approximately 6 ft. from the floor, and of not less power than 25 watts, will provide for comfortable reading by the patient, and for nursing attention and treatment by the staff, without glare affecting other patients. In two hospitals known to me, these bracket lights have their broad base detachable from a flat hook on the wall, thus providing all the advantages of a movable side-light for examining throats or eyes or skin rashes. They have, however, the disadvantages of dangling flexes, collecting dust, and it is more usual to prefer a fixed wall light over each bed and, between each pair of beds, a point into which to plug a side-light. Dr. Gordon Pugh, of Queen Mary's Hospital, Carshalton, recommends a less expensive alternative, by which the interval between windows is wide enough to take two beds. One wall bracket light with a spherical white glass shade is shared between the two beds. The light is thus oblique, and does not cause glare to a recumbent patient.

With a system of lights over bed heads, very few central lights are needed for general illumination in large wards, perhaps one over a sterilizer table or drug cupboard and one over a fireplace for the use of ambulant patients. A shaded light must be provided over the nurse's table and one or two ceiling lights with inverted

shades as night lights. The switches for the latter should be separated from the other switches to prevent bright lights being switched on in mistake at night. Another minor improvement is the effort now being made to provide noiseless switches.

Having regard to the times, I have in this paper avoided referring to methods of ventilating, heating and lighting hospitals, which, although possibly better than those now in use, involve very heavy expenditure. When electricity can be supplied sufficiently cheaply for heating wards and for regulating ventilation, the time may come when it will have as complete a monopoly in those services as it now has in regard to illumination.

Discussion.—Dr. ALEXANDER JOE said that he was a whole-hearted believer in the value of fresh air in the treatment of the acute infectious diseases, and workers in this field owed much to the tuberculosis experts for ideas as to the ways and means of providing it. He had found fresh air particularly of benefit in the treatment of infections of the respiratory and upper air tracts, and generally it induced rest and sleep and promoted appetite. It had an undoubtedly beneficial effect on inflamed mucosa and on that account probably did something to lessen the period of infectivity, whilst the dilution of infection in well-ventilated wards was one of the most important methods of minimizing "droplet" cross-infection. He considered that for the treatment of such diseases as the septic type of scarlet fever, whooping-cough and measles with their associated bronchopneumonia, open-air treatment was essential, and that in the present epidemiological type of scarlet fever, probably the only contra-indication to open-air treatment was when nephritis had developed. As to the methods of carrying out the treatment, he was convinced that open-air with adequate safeguards against strong sun or bitter wind was superior to a roofed balcony, and a roofed balcony to the open-sided ward. He agreed with Dr. Watt that in a ward abundant ventilation was of more importance than the maintenance of a uniform level of temperature, and in his own practice he did not worry unduly about a low ward temperature, but insisted on the body-warmth of individual patients being maintained in bed by hot bottles, adequate personal and bed clothes. The latter method, whilst imposing a strain on the nursing staff, *could* be carried out, and in his hospital patients who had whooping-cough and measles were put out in their cots on the ward balconies for part of the day all the year round, except on days when the wind was bitterly cold.

Mr. H. W. BINNS showed some photographs of a hospital for totally disabled soldiers and sailors (St. David's Home, Ealing) of which he was the architect. He explained that this home was built to accommodate the worst type of the incurable illnesses brought about by war service, such as encephalitis lethargica, rheumatoid arthritis, etc. Practically all the patients were incontinent and from thirty to fifty per cent. entirely bedridden, and it naturally followed that they were inmates for a considerable period.

Fig. 1 (p. 88) was a view taken inside the "cloister" which formed one end of a four-sided "garden courtyard" around which the new wing had been built. The two-storey building on the opposite side of the courtyard had male nurses' accommodation on the upper floor. This photograph also showed one of the small wards with a certain amount of extra cross ventilation at either end. Mr. Binns drew attention to the domestic treatment of the cloisters such as the limed oak beams in the ceiling, the design of the lamps and the treatment of the tile floor, etc., all of which, although they did not affect the efficiency of the building, helped to give it an "atmosphere" different from that generally associated with a building of this kind.

Fig. 2 showed the cloisters occupied by beds, as seen from the garden. The windows on the back wall were sliding and glazed with "vita-glass" so that in very hot weather the patients had all the benefit of being out of doors without the discomfort from the sun and with controlled protection against draughts.

Fig. 3 showed the interior of one of the larger wards and attention was drawn to the two-faced fireplace which had its chimney passing under the floor. Attention was also called to the windows with pivot-hung casements to the lower parts, and hoppers falling inward above the transomes were also shown on this photograph. The colour scheme comprised a brown oak wood block floor, saxe-blue dado and light primrose buff walls and ceilings. The windows were kept low to enable patients in bed to see the gardens, etc.

FIG. 1.

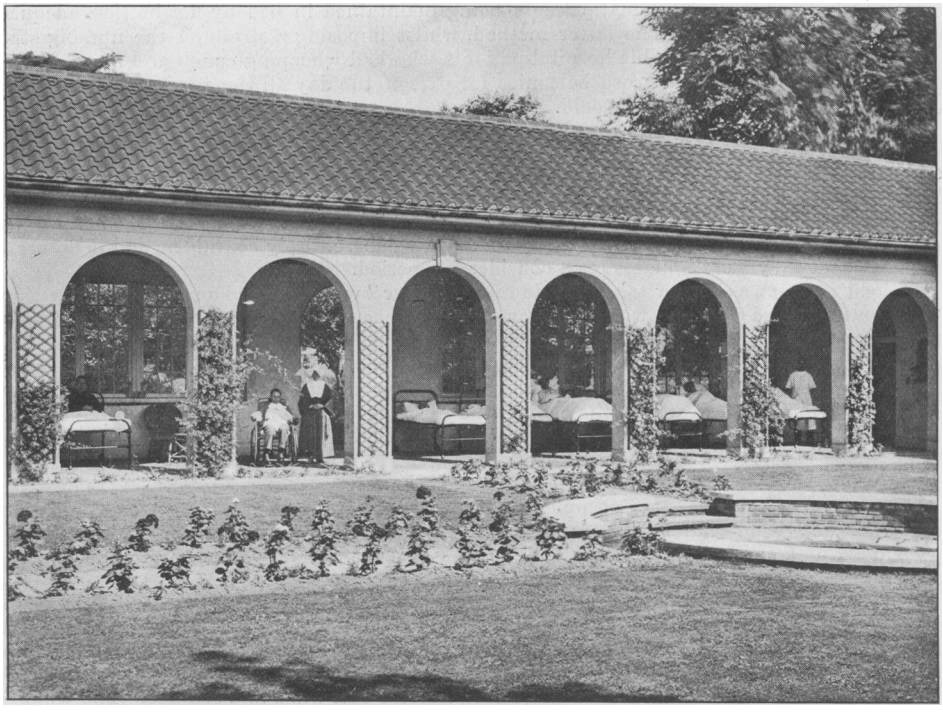

FIG. 2.

FIG. 3.

FIG. 4.

In a hospital of this kind with plenty of land available, and in which a one-storey building was an advantage, a cloister was better than a verandah as it did not take away light from the wards and enabled the patients to have complete change of scene and environment and also to interview their families in a garden instead of in a ward, with the advantage of a further degree of privacy.

Mr. Binns then showed some photographs of St. Vincent's Orthopædic Hospital at Eastcote, of which he was appointed the Architect some four years ago.

Fig. 4 showed one of the new wards with similar accommodation to that in the old type of ward, but designed to be more cheerful, lighter, and better controlled in regard to ventilation.

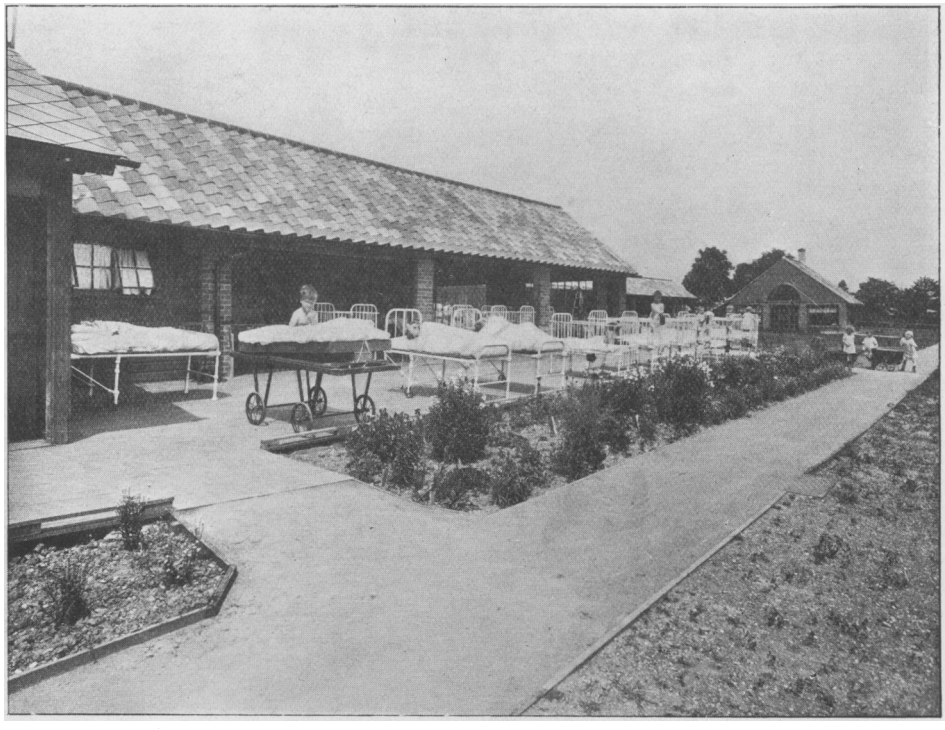

FIG. 5.

Fig. 5 showed the new babies' ward which had just been completed, with its broad teak platform on the south-east side where the three rows of beds which the interior of the ward accommodated could be pushed out. It did not, however, clearly show the side windows which had sliding control, or the sliding glazed screen which could shut off two-thirds of the ward in very bad weather.

Mr. L. G. PEARSON said that Dr. Watt's paper was a valuable contribution to a subject which was the crux of hospital planning. The ventilation and heating of the ward decided the plan to a large extent, and in emphasizing the importance of cross-ventilation Dr. Watt was a refreshing contrast to some members of his profession.

Dr. Watt's suggestion that the small ward, particularly the four-bed ward, with a large window on one side and fanlights to a ventilated corridor was the solution of the difficulty of supplying fresh air without draughts, seemed to point the way for the future of hospital planning. It would radically affect the lay-out of the plan, and would enable the beds to be placed parallel with the external wall, much to the benefit of the patient. The difficulty would be to satisfy the nursing staff, who preferred the large open ward with right-angle

beds, on account of supervision. But it was to be hoped that the "parallel bed" ward would be adopted widely in this country as it already had been on the Continent.

With regard to heating, low-pressure hot-water radiators under the windows still appeared to be the most suitable for wards, though panel heating and other forms, such as floor heating, had their uses. However, changes were to be expected when the cost of electricity went down, in fact one might hope to see the radiator freed from the supply pipe, and it might be possible to place it in all sorts of positions—for instance, attached to the foot of the bed.

Electro-vapour radiators had already been installed in a hospital in the West of England, and this type seemed to have great possibilities. At the same time it was to be hoped that there might still be a use for the open fireplace where cheerfulness and additional warmth were required.

Fleet-Surgeon W. E. HOME said that in a hospital ship between Havre and Southampton during the late war, the patients in the large saloon slept badly as a rule, until it was found that the large fans were out of order, and when these were put right, the patients in the now well-ventilated ward, slept vastly better.

Mr. T. B. LAYTON said he feared that he and his fellow clinicians paid lip-service to ventilation, light and heat, but did little to help in the application of these principles.

Much of his own work was concerned with the problem of how to prevent the patient recovering from acute streptococcal disease from passing into a stage of chronic illness. He was convinced that the best treatment for this stage of streptococcal disease was the same as the treatment for tuberculosis. He found himself in agreement with most of what Dr. Watt had said, and especially with the opinion that in the treatment by fresh air and sunlight, the latter was the less important factor, the passage of cool air over the surfaces of the body the more important. He believed that there was still too great a fear of cold, especially in the development of nephritis. He wished specially to note two of Dr. Watt's points, namely, the psychological effects of these things, and the fallibility of the human factor in management, but he was disappointed that Dr. Watt had spoken with such a luke-warm feeling for balconies and verandahs. His own feeling was that adequate balcony accommodation should be an integral part of every ward to-day.

With regard to the "fallibility of the human factor," there was too great a tendency on the part of the medical profession to leave the airing of the wards to the nursing staff so that their patients might become subjected to the whim of a Sister. He knew of a ward which at times stank like a fried fish shop, and another the windows of which were so widely opened that the December gales blew through them, so that all those within them who were not in bed were pinched with cold. The question of keeping the wards at a lower temperature than had been the custom became a difficulty when some of the patients were up, as though it was easy to keep patients warm when they were in bed, it was less easy to do so when they were about.

Lastly he would ask whether orange had been tried as a colour for the walls.

Dr. T. S. MCINTOSH said he had been pleased to hear Dr. Watt say that exposure to the direct rays of the sun, without the accompaniment of currents of air, might be far from pleasant for the patient. Exposure to sun right out in the open was one thing, but it was quite another if the patient was lying in a ward or even on a verandah. To lie in a ward with the sun pouring in on one through the window could be very trying. Even verandahs which acted as sun-traps might be very uncomfortable, and a verandah with a southern aspect and a glass roof could be quite intolerable. In such circumstances one usually found that the glass roof had been painted green to exclude the sun's rays.

The temperature of wards was usually too high, and the uniformity of temperature produced by central heating was bad. Unfortunately, nowadays, everything was planned to save trouble and it was less trouble to keep a constant dead level of temperature than to vary patient's clothing with varying temperatures. It was not so good for the patients, however. Apart from certain special forms of illness which might call for uniformity of temperature, patients, like healthy people, were the better for variations which called for a response from the heat-regulating mechanisms of their bodies.

He, Dr. McIntosh, agreed as to the desirability of small wards, but they caused difficulties in planning unless one was content with direct openings into the open air on one side only. One side of the small wards was bound to open into a corridor. In the case of single-storey pavilions, by making the corridor lower than the wards, there could be windows opening over the corridor, but in multiple-storey buildings this, of course, was not possible.

Dr. E. W. GOODALL said that changes in hospital design had been going on for a long period, but they were not always for the best. Some of the hospitals built a century or so ago were anything but an improvement on those erected at an earlier date. For instance, the surgical wards at Guy's Hospital, which were part of the original building, were much better as regards light and ventilation than those in the large block—the medical wards—which were built later. With regard to the height of the windows above the floor: in the days when typhus and typhoid fever were very prevalent, the windows were placed high so that delirious patients should not get out of them. Doubtless, bars could be placed across windows that came nearer the floor, but they gave a prison-like appearance to the wards. He was surprised that Mr. Pearson anticipated opposition to the arrangement of small wards of from one to four beds each; he would not meet with objections from medical men, at any rate from those who had to do with fever hospitals. But, of course, there was the question of cost—both of erection and of maintenance—to be considered. As to the question of the exposure of patients more or less in the open-air, the public required education; ignorant people still had rooted objections to open windows.